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Our Most Important Mineral—Water

The postwar uranium boom, the oil "excitement" of the twenties and thirties, and the earlier gold rushes are eclipsed today by a more widespread and compelling search for a far more important mineral —water. In many places the need for it is growing desperate: in the Great Basin of Nevada and adjacent parts of the United States and northern Mexico; in most of North Africa; in the disputed Thar of Rajputana, western India; and in the Gibson Waste of Western Australia.

These great desert areas have long stood out as parts of the earth that defied intensive settlement, yet the human race has recently registered gains in many of them, bringing under the plow land hitherto apparently unredeemable from drought and desolation. Now, however, the need for water even in these desert belts is probably not as urgent as in the more closely populated, agricultural and industrial centers of the world, where fluctuations of inadequate water supplies are promptly felt by many. It is in such regions that the population is mounting rapidly, largely in response to the rise in living standards reflecting the growing use of the machine. With this go higher requirements for food, especially cereals and livestock, and for water.

All this has suddenly, almost explosively, burst upon our consciousness. Small groups—states, cities—are struggling with their neighbors for the control of water resources. A water-conscious world discusses water reserves and water conservation, not only national but international. Is the supply limited or infinite? Does wise utilization mean more than repeated cycles of use, discharge, and recovery? Where can needed additional sources be found? How shall enough throughout the year be assured, rather than too much at times? What scientific, technical, economic, and juridical problems are involved in securing a steady supply? The thoughtful citizen, even if situated so fortunately as not to be directly and critically concerned, is likely to be at least disturbed on contemplating these matters.

In one way or another water is, of course, a basic factor in the dynamics of weather and climate, of streams and lakes, tides and oceans. It is fundamental to many mineral-forming and mineral-recovering processes. Latterly it has become a major source of power, playing a role in fixed-power plants about equal with that of coal, petroleum, and natural gas in the United States, a nation exceptionally rich in the mineral fuels. In countries such as Norway, Switzerland, and Italy, with steep slopes and moderate to copious precipitations at higher altitudes, it is even more significant, being by far the most abundant and widespread power source.

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SOURCES OF WATER. Three things may happen to water after it falls as rain or snow. It may go back into the atmosphere by evaporation from the surface of the land; it may flow over the surface in streams to enter swamps, lakes, or the ocean (*runoff*); or it may seep into the soil or rock and be stored underground, perhaps reappearing locally elsewhere as a spring. The proportion going to each of these destinations varies with such factors as rate of precipitation, atmospheric dryness, and porosity of the ground. That which sinks directly into the ground is added to the subsurface accumulation, filling almost all open spaces beneath the surface. The top of the zone of saturation fluctuates seasonally or irregularly with variations in precipitation, capillary movements upward, and the like. This top level is the *ground water table.*

Any porous rock holding water in crevices or cavities or between its mineral grains is an *aquifer.* Aquifers are largely solid or partly cemented rocks but may be sand or gravel. Aquifers and adjacent rocks may be folded, then exposed by surface erosion. Water can enter the aquifer at the exposed edges and flowing down, be entrapped. Under pressure from the water upslope in the aquifer, this *artesian* water will rise in a well drilled to its level, as shown in the diagram. If, because of differences in elevation between the intake area and the head of the well, the upward pressure on the water is great enough to more than balance the friction developed in the trickling flow in the aquifer, a spouting or *artesian well* results.

The enormous amount of water stored in an aquifer, either through long ages of slight rainfall (as in deserts) or at periods of heavier precipitation (as locally during the great Ice Age), may sustain desert farming for some time with artesian supplies of incalculable value. The great deserts of central Australia have depended upon such reserves; and the farm and ranch water needed in the states just east of the Rocky Mountains, such as eastern Colorado and the Dakotas, is supplied largely by water from deep artesian wells.

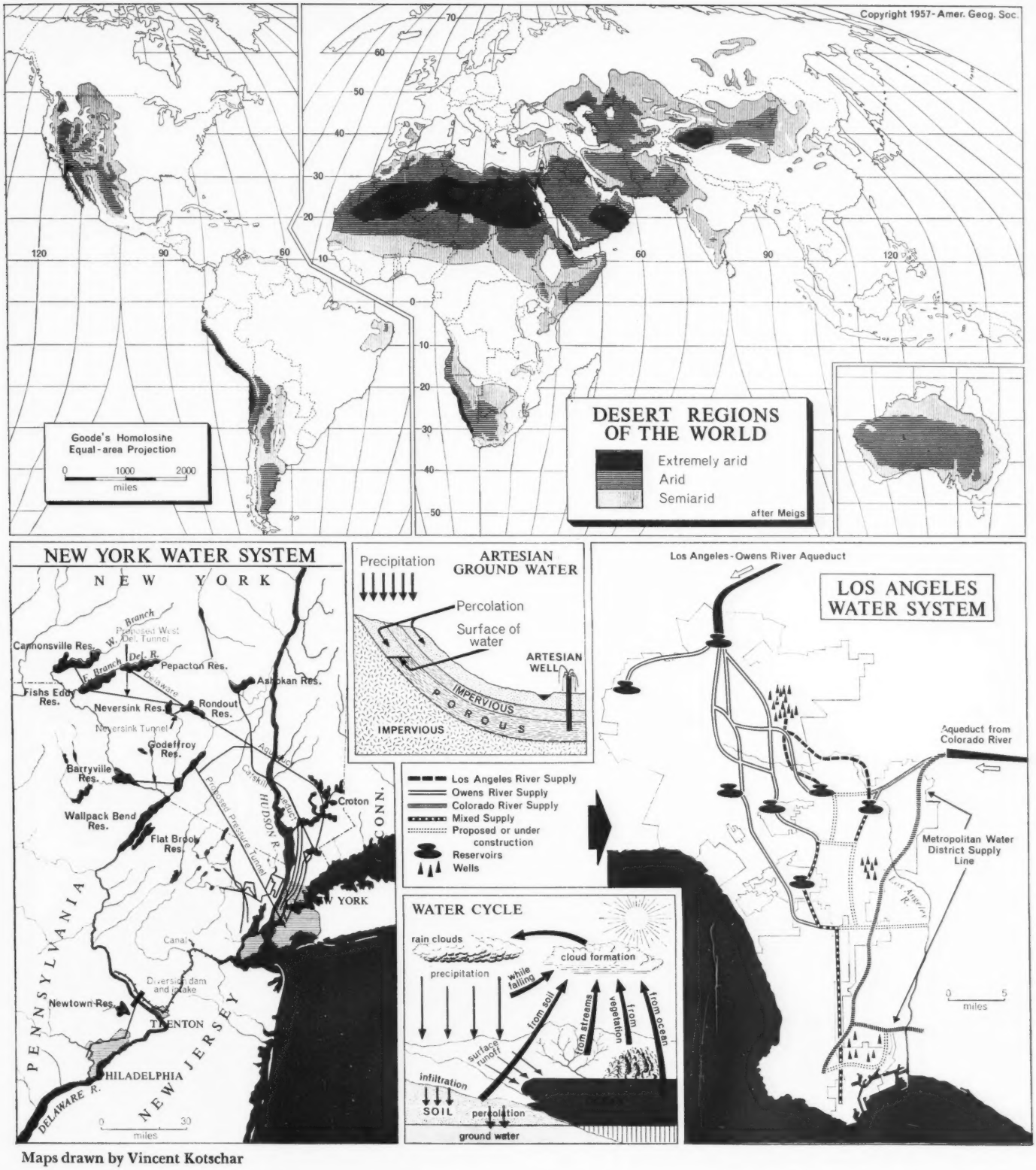
PROBLEMS OF SUPPLY. Water for three major uses, irrigation, industry, and home, has to meet two chief requirements, quality and quantity. A fourth major use, power generation, likewise calls for quantity, but quality is obviously less important except that water too full of suspended clay and fine sand rapidly silts up storage reservoirs. One notable example of this was the New Lake Reservoir at Austin, Tex., which in 13 years became 95 per cent filled, so that its use virtually ended in 15 years.

Irrigation water has as a prime requisite that it be not too laden with the salts which accumulate near the surface in desert regions and are deleterious to most useful plant life. Otherwise quantity is far more important than quality. In 1950 irrigation water used in the United States amounted to 88 billion gallons a day, the largest single "destructive" use of water for any purpose. "Destructive" is here applied to stress the fact that water spread on the land cannot be re-used before it has been dissipated into the sky by evaporation and reprecipitated, perhaps far away, as rain or snow. By contrast, water used for generating power can, after such use, serve for irrigation or other purposes.

Far more stringent are the specifications for water for industrial purposes. Quantitatively the use in industry, increasing from year to year at a staggering rate, is now approaching that in irrigation, having been 82 billion gallons a day in 1950. Many large industrial establishments use as much water as a good-sized town. Indeed, an adequate water supply is a major consideration in the development of numerous larger industries. This is notably true for chemical industries, for which water is an essential ingredient or serves as a cooling or steam source; metallurgical industries, particularly ironmaking and steelmaking and the related coke ovens, for which water is almost the sole cooling agent; and such widely diverse manufacturing processes as papermaking, distilling and brewing alcoholic liquors, oil refining, and artificial-silk production. In the chemical and textile industries particularly, water has to be free from deleterious constituents, among which lime carbonate is one of the commonest, giving a "hard" water inimical to use in laundries, fiber manufacture, and production of certain foods.

In addition, water, being an excellent flushing agent, is the main answer to the problem of waste disposal in industrial and population centers. A special modern development of this use is in plants concerned with uranium utilization; much of their waste must be prevented from later reaching human consumption in any way.

The quantity of water required for internal use by animals, especially man—in a word, the domestic use—is less than for most other uses, having been only some 17 billion gallons a day in the United States in



Maps drawn by Vincent Kotschar

1950. However, its specifications for quality are the most exacting. Newspapers are full of discussion regarding the use of fluorine to reduce tooth infection and decay. Many other ingredients in water are physiologically comparable in importance. Certain kinds of goiter are distributed in geographical belts related to the lack of iodine in the local drinking water, derived from iodine-deficient glacial deposits. Far more widespread is the dissemination through water of parasitic diseases—bacterial, virus, or proto-

zoan. In limestone regions especially, the water may travel appreciable distances through subterranean channelways and caverns; such water is not filtered or aerated to the same degree as in most less freely channeled rocks such as sandstones. In consequence, in limestone regions epidemics of diseases of the alimentary tract, such as typhoid fever, are fairly common. In tropical countries the plentiful bacteria may not be eliminated by natural filtering and oxidation; there amoebic dysentery, chronic or fatal infections of the liver, and other ailments are widely transmitted by unclean surface or underground water.

These dangers may be guarded against in various ways. As a rule, city water supplies are carefully filtered, commonly by passage through beds of somewhat porous material, like sand. Fine suspended material, such as clay, and some undesirable salts may be precipitated by treating the water with alum or lime, which yields jellylike colloidal precipitates that carry many suspended impurities, including bacteria, to the bottom of the basin. If excessive for domestic or industrial use, lime can be removed by "zeolitization," in which water is passed over a compound that extracts the element calcium from the solution and substitutes the less objectionable element sodium.

Much fairly aseptic water, once highly impure, can be recovered from the liquid that results from flushing sewage out of the large cities. The sewage and its associated water are made innocuous by bacterial treatment (the activated-sludge process), which ultimately kills off the infectious organisms. The resulting water, though unsuited to domestic use, can be used for irrigation and represents a major water saving. Several California cities have installed large plants for sludge activation which give a total yield of at least 50,000 acre-feet of "sewage effluent" water a year. Treatment of sewage before discharge greatly reduces the danger of infection by water in downstream cities. Thus, along the Ohio, for example, waters become clean even though they received sewage from upstream cities, as provided in the Ohio River Valley Water Sanitation Project, which affects 20,000,000 people in an area of 200,000 square miles.

THE STRUGGLE FOR CONTROL. Despite the many methods for increasing quality and quantity of water supply, communities are in constant struggle to acquire the right to more of it. This explains the present conflict over the Jordan River and some of the friction between western India and the eastern part of western Pakistan. It may yet cause serious disagreement between the United States and Mexico. The Canadian and American governments are much concerned over the distribution of water at Niagara Falls.

Within the United States, these problems are most acute in the West, especially the Southwest. Colorado, for example, is in conflict with states farther down the Colorado River because of its threatened use of headwaters, to the detriment of those downstream who need the water. Repeated suits, carried up to the Supreme Court, have been instituted between the cities of New York, Philadelphia, and Trenton regarding the Delaware River and its headwaters. At issue here, as elsewhere, is the *relative* need of the competing communities. The other cities contend, with considerable justice, that New York should use the Hudson River, despite the purification problems that this would pose.

Surface waters can be measured fairly easily and their sources determined, but how much more difficult are the problems related to underground water! Like petroleum and natural gas, water is a "feral" mineral—"wild" in the sense that it can move from place to place and is not fixed for exploitation like coal, iron ore, and most other mineral substances. A property owner counting on water under his ground may find that a neighbor, pumping his own well more rapidly, has exhausted not only the ground water reservoir of his own subsoil but also that of the adjoining land. A great body of law concerns rights and responsibilities of those who own or use water supplies. Miners, for instance, cannot capture and sell water pumped from their workings; they must release

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it, though they may first use it, so that the farmer downstream can also have some.

MAINTENANCE OF SUPPLY. Surface water supplies may be maintained by storage reservoirs, which serve for power generation or flood control or both. The waters behind the famous Aswan Dam on the Nile and the Hoover Dam south of Las Vegas, Nev., are examples.

Underground reserves are commonly maintained at desired levels in four ways: (1) by reducing runoff and thus increasing natural underground recharge; (2) by artificial recharge; (3) by special methods for control of underground losses; and (4) by curtailing consumption through rationing, metering, or the like. Controlling forests and pasturelands, by preventing excessive stripping of vegetation, cuts down soil erosion and humus removal and thus maintains the porous material that favors recharge. Contour plowing likewise conserves soil and promotes percolation. Natural lakes and swamps and small dams on streams create standing water and give time for recharge.

In several of the smaller cities of New Jersey water is recharged into the ground from wells drilled down to a known aquifer. In the Los Angeles area special "recharge basins" promote seepage into underground storage by spreading water artificially over flat areas or feeding it into trenches. Artificial recharge, like filling an underground sponge, has the disadvantage that the "feral" water so stored may seep away, but careful study of the local geology can reduce this danger.

Special methods for trapping water with underground dams and wells are applicable in some deserts. At Chott Chergui, in French North Africa, with a rainfall of only 11 inches, French geologists and engineers have collected the infall of the natural basin underground and used it for an assured flow to power stations and to a large irrigation project. An even more recent, different undertaking in the Thal desert of western Pakistan will reclaim by careful recharge and irrigation an area of one million acres, with resettlement into villages.

The excessive use of underground or surface water at rates beyond the recharge rate may be discouraged by rationing. In an irrigated farming region this is well understood, and a water thief is prosecuted as bitterly as a horse thief among cowboys. Several years ago the growing community around Roswell, N. Mex., dependent on a local artesian basin, regularly consumed more water than entered the aquifers of the basin; water levels in wells, therefore, steadily lowered. Alarmed by the danger of protracted drought and industrial paralysis, the community instituted strict rationing. This was highly successful,

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